were more frequent than specific variations. Hitherto no exception has been found to the required rule. One group of fungi tested (Hymenomycetineæ) gave a line with a slope very little exceeding unity (1·08), but the figures found for flowering plants lie between the narrow limits 1·38 and 1·64, with an average of about 1·43. Snakes and lizards both give a figure very near 1·50, and the Chrysomelidæ about 1·37.

The development of a more complete theory may in some degree modify conceptions and interpretations, but the results so far obtained suggest that the basic principle put forward is correct.

Inasmuch as all families, both of plants and animals, show the same type of curve, whether graphic or logarithmic, it would appear that in general the manner in which evolution has unfolded itself has been relatively little affected by the various vital and other factors, these only causing deviations this way and that from the dominant plan. And since, assuming that genera "throw" other genera and species, it was predicted that the logarithmic curves would be straight lines, and it was then discovered that they actually were so, it is probable that the assumption was correct. But if this be so, then not only must evolution have been by mutation, but it must also have been, as one of us has contended for many years, by mutations that were at times of rank sufficient to give rise to Linnean species, genera, or even families. Not only so, but evolution must have proceeded on the lines of Guppy's theory of differentiation, the larger genera, and the species of larger area, being the parents of the smaller: *i.e.* it must have proceeded on the whole in the reverse direction to that postulated by the Darwinian theory, as one of us has long maintained.

Finally, it is clear that geographical distribution has been largely mechanical, the general effect of the many factors that are operative being to cause species to spread at a fairly regular speed (differing for each), so that spread forms a measure of age.

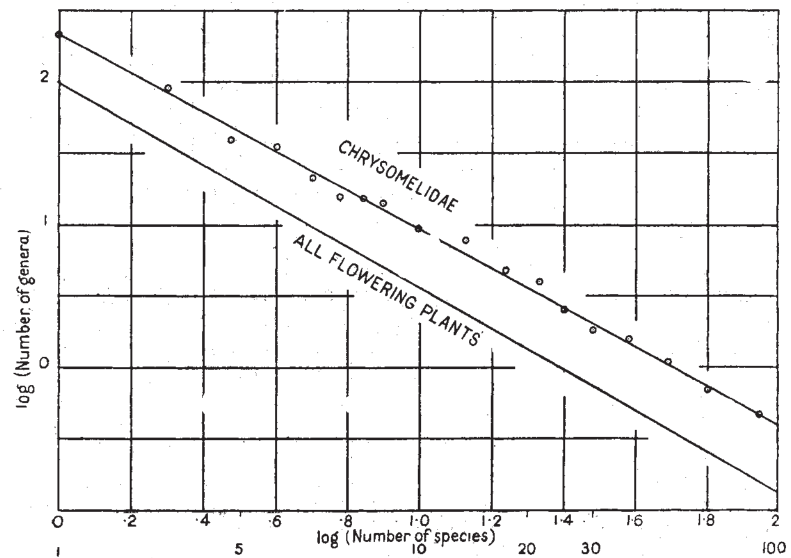

FIG. 4.—Log. curve for chrysomelid beetles.

Space does not permit of detailed argument, which must be left for forthcoming books; but a couple of hours' work at statistics of genera (by sizes) will suffice to make clear the general position taken up.

Some Problems of Long-distance Radio-telegraphy.[1]

By DR. J. A. FLEMING, F.R.S.

II.

ANOTHER cause operating to effect a separation of the positively and negatively charged dust is found in the viscosity of the atmosphere. Roughly speaking, the viscosity of a gas is that quality of it in virtue of which fine particles experience a resistance in moving through it. Maxwell showed long ago that the viscosity of a gas is independent of the pressure over wide limits. Crookes continued these researches and demonstrated that between atmospheric pressure and a pressure of about one ten-thousandth of an atmosphere the viscosity remains constant, but that when the pressure falls below this last figure the viscosity very rapidly decreases to zero. Again, both Maxwell and Crookes found that the viscosity of hydrogen is about half that of oxygen or nitrogen. The viscosity of air at 760 mm. is 0·00018 C.G.S. units.

Sir George Stokes proved that if a small sphere of diameter d and density σ is falling through a gas of density ρ and viscosity μ under the action of gravity it will attain a final velocity v such that

$$v=\frac{1}{18}\,\frac{d^2 g}{\mu}(\sigma-\rho),$$

where g is the acceleration of gravity. This explains the extremely slow rate of fall of water particles constituting clouds, and also the very slow settlement of fine dust particles through air.

The positively-charged solar dust particles are probably larger than the negatively-charged particles, as the latter consist of electrons having condensed round them molecules of gases, probably hydrogen and helium, gathered from the solar chromosphere. Accordingly the negative ions will be brought to rest before the positively-charged particles and gas viscosity will assist the separation.

But Stokes's expressions apply to smooth spheres and not to irregularly shaped particles. Also, if the diameter of the particle is much less than the mean free path of a gas molecule, the expression for the frictional resistance, $3\pi d\mu v$, must be divided by $1+2\alpha L/d$ where L is the mean free path of a gas molecule and α is a constant depending on the nature of the particle and its form.

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[1] Continued from p. 143.

If, then, particles of dust enter the highly rarefied upper hydrogen levels of the atmosphere, they will experience very little retardation until they reach that level (about 100 km.) at which viscosity begins to increase rapidly to its normal or full value, but then they will be very quickly brought to rest even in spite of their high initial velocity.

Hence none of this dust will penetrate below a certain level in the atmosphere, probably from 60 to 80 km. It will be stopped and held by air viscosity. The moment its velocity falls off the forces tending to separate the oppositely electrified particles will also decrease, and the oppositely charged particles may then neutralise each other. The result will be, as I think, to give the highly conductive layer in the earth's atmosphere a tolerably well-defined under-surface determined by the very rapid rate at which air viscosity rises with increasing air-pressure. Hence it is clear that when the dust particles reach a certan level their earthward progress will be practically arrested.

Meanwhile the region above this will be left impregnated with the smaller and lighter negative ions which are moving slowly or quickly in directions oblique to the earth's magnetic meridians and winding their way spiral-fashion towards the regions of the magnetic poles. The explanation of numerous astronomical, meteorological, magnetic, and atmospheric electric phenomena by the aid of this hypothesis of electrified solar dust projected by light pressure from the sun to the earth has been worked out in great detail by S. Arrhenius, K. Birkeland, W. J. Humphreys, and others. This solar dust hypothesis seems to be supported by the observations of Newcomb, Yntema, Abbot, and W. W. Campbell on the fact that on clear moonless nights the sky sends to us more light than can be accounted for by the sum total of starlight, and that this extra light is notably greater near the horizon than at the zenith, and also by the spectroscopic observations which show the green auroral line in all parts of the tropical sky on moonless nights.

In addition to this hypothesis of a permanently conducting upper region of the atmosphere we are compelled to postulate that beneath this there must be a region of variable ionisation due to solar light, which is ionised during the day above the level of clouds, dust, and water-vapour, but more or less dis-ionised during the night.

Dr. Eccles has worked out the consequences of assuming an atmospheric region in which ions of molecular mass are present, possibly formed by the action of ultra-violet light on molecular groups which are photo-electric. The presence of these heavy ions acts so as to produce what is in effect a reduction in the dielectric coefficient and therefore an increase in the velocity of electric waves through the ionised region.

This action may be illustrated by a magnetic parallel. If iron spheres were placed in a magnetic field they would be magnetised, but owing to the reverse action of the free poles the magnetic force in the iron would be less than the force at that point if the iron were not there. Hence the magnetisation produced is not that which corresponds to the external impressed magnetic force, but to the reduced magnetic force.

In the same manner if heavy ions are present in the air the orderly arrangement of them by the impressed field reduces the effective electric force in the space occupied by them, and this is equivalent to a reduction in mean dielectric constant. But the velocity of the wave is inversely as the square root of the dielectric constant, and therefore the wave speed is increased. From this it follows that if there is a gradually increasing density of heavy ions of both signs as we rise higher in the atmosphere, there will throughout that region be a gradually increasing electric wave velocity with height, and therefore an effect which has been called *ionic refraction* in virtue of which the higher levels of a plane electromagnetic wave advancing over the earth will advance more quickly than the lower parts. Hence the wave track will follow round the earth's curvature and an obliquely rising ray may even be brought down again to earth by an action resembling that of an inverted mirage.

The very complicated phenomena connected with freak signalling, the great effect on signal strength of the sunset and sunrise periods, the curious anomalies in the difference between daylight and night-time radio-transmission for various wave-length, and the variation in range between north–south and east–west transmission have all received certain plausible explanations on the theory of a variable ionisation by sunlight of the atmosphere, and its irregularities at the bounding surface of the earth shadow cone as it sweeps through the atmosphere. The atmospheric ionisation at this surface will tend to become "patchy," and will therefore bestow a certain increased opacity and increased reflecting power on that region for electric waves just as small air bubbles in water give it a certain opacity for visible light.

The general increase in range of radio-communication by night is accounted for on this theory as due to partial removal of the ionic refraction which in the daytime brings the ray down again to earth at ranges less than that due to the guiding properties of the permanently ionised higher layer.

There are, however, curious exceptions to this in the case of certain long-wave transmission. Senatore Marconi long ago pointed out that with certain wave-lengths from 5000 to 6000 metres transatlantic radio signals are often stronger by day than by night. These anomalies and others recorded by Dr. Eccles seem, however, to meet with reasonable explanations on the ionic refraction theory.

On the other hand, our difficulties are great in bringing these hypotheses to critical test. The atmospheric region in which the phenomena take place is far beyond the reach of our meteorological sounding balloons or possibilities of testing the actual ionic distribution. We can only, therefore, patiently continue to collect the facts and trust to cautious inductive reasoning and observations to give us the true interpretation of them. All the phenomena seem, however, to point to the existence of three superimposed layers in the atmosphere: one, the higher, beginning perhaps above 80–100 km., which is permanently ionised with negative ions. The other, the middle, which has in part variable ionisation, depending on the position of that part with regard to the sun. The third or lower level has a relatively small ionisation, but electromagnetic waves travelling in it may have their energy considerably affected and reduced by the nature of the earth's surface over which they are moving. Powerful absorption is caused by some soils and by vegetation for certain wave-lengths.

From the earliest days of long-distance wireless telegraphy the difficulties in reception due to vagrant or natural electric waves and atmospheric electric discharges passing down the receiving aerial have been the bane of the wireless telegraphist. These waves create sounds in the telephone in aural reception which often drown completely the signal sounds and make false records in the case of printing or photographic reception. In the case of telephone reception, these noises have been classified into (1) rattling or grinding, (2) hissing, (3) clicking or snapping, and (4) crashing noises. These last two seem to be associated with thunderstorm conditions. Having regard to the fact that the positive atmospheric electric potential gradient of the earth increases at the rate of about 100 volts per metre of ascent, it is not surprising that aerials several hundred feet high may be traversed by quite large currents, due to this cause alone, which may utterly swamp the feeble signal currents. The strength of a signal or noise in the telephone is generally estimated by its "audibility," and this is measured by ascertaining the resistance S of the shunt which must be put across the telephone of resistance R just to render the sound inaudible to a normal ear. The audibility A is given by the expression $A=(R+S)/S$. Hence the audibility is unity for a just audible sound. We can in this way measure the audibility of a signal on a background of disturbing noise, and a readable signal is generally obtained if the ratio of signal audibility to stray audibility is more than 25 per cent.

Owing to the serious extent to which these strays hinder regular reception, especially at certain times of the day and year, an enormous amount of attention has been given to their study and to the problem of eliminating them. They are most troublesome in the summer and during the night, and more severe in tropical than in temperate climes. Even in our latitudes they hinder reception at times immensely. Dr. L. W. Austin has stated that receiving at Washington, U.S.A., with a simple loop aerial from high-power radio stations in Europe with aerial sending currents up to 300 amperes, signals were unreadable for about 2000 hours a year. In tropical countries over long-distance circuits the power required to get a signal through may be often from six to eight times that which must be used at favourable times, and there are short periods when signalling is absolutely impossible. Having regard to the effect such interruptions have upon the earning power of a commercial station or upon certainty of communication in time of war or other urgent occasions, the problem of elimination of strays is perhaps the most important of all the practical questions connected with long-distance wireless telegraphy. It has been the subject of countless patents already. Early attempts went on the supposition that the strays were highly damped vagrant waves or had particular frequencies and could be eliminated by giving the receiving system a very pronounced resonance and making it a so-called stiffly-tuned circuit. These methods had a very limited application, for the reason that any impulse given to the receiving aerial sets it in electric vibration with its own natural period. Then, again, a number of inventions depend upon the peculiar properties of certain detectors, such as crystals and thermionic valves, in limiting the current which they pass or rectify. One most practically useful discovery was that by giving to the spark or wave train in the case of spark systems, or to the beats in the case of C.W. heterodyne reception, a regular frequency of 500 or 600, thus imparting a rather shrill musical sound to the signal, the ear could much more readily fasten attention on it even against a background of irregular but louder noise due to atmospherics.

Dr. de Groot made an immense number of observations on stray strengths at various hours of the day and months of the year about 1916 in the Dutch East Indies, and prepared diagrams showing the mean stray strength for various hours for each month of the year. From these he prepared a diagram giving the hourly stray strength during the day averaged throughout a year. The results were that in general the strays were more numerous and stronger during the night than during the day.

We have seen that there must be a certain intermediate but high-level region in the atmosphere in which the gases are ionised by the ultra-violet sunlight during the day, but re-combine again during the night. This region lies beneath the permanently ionised layer. In this permanently ionised layer there are drifting collections or masses of positively electrified and negatively electrified solar dust. If these masses are drawn together by their electric attractions or commingled, it is highly probable that electric recombinations will occur, which would generate electric waves. Suppose, then, that we assume the origin of a certain part of the strays to be in the upper permanently conductive layer of the atmosphere, these natural waves would find a certain obstacle to their downward transmission in the conductivity produced by the ionisation of the middle layer of the atmosphere by day. But at night-time this middle layer ionisation largely disappears and the natural electric disturbances in the upper layer would more easily find their way down to the earth. In other words, there would be a more unhindered access for the strays to descend. Hence in the night-time they would be more numerous and more apparent in the effect they produce on receiving appliances.

The view that the strays which produce continuous rattling or grinding noises in the telephone have their origin in the high-level permanently conductive layer of the atmosphere was also put forward by Dr. de Groot, and he has employed ingenious arguments to obtain an estimate of the height of this layer, which he places at between 180 and 200 km.

These estimates must, however, be brought into comparison with the observations which have been made on the heights of the aurora. Störmer has made precise measurements of the parallax of the beams and arches of auroræ by photographic observations at places connected by telephone, and found, out of 150 observations, that the lowest occurred at 40 km. and the highest at 260 km. Much, however, depends upon latitude and the height of the region ionised by cosmic dust may be greater at the terrestrial equator than at the poles. The whole subject is of great importance in connection with meteorology and terrestrial magnetism, and invites the co-operation of physicists, astronomers and meteorologists, as well as radio-engineers.

The matter is, however, of such immense practical importance in radio-telegraphy that improvements or inventions connected with it are generally kept as carefully-guarded secrets, at least, for some time. Senatore Marconi spoke recently of inventions due to himself and his technical staff which promise a great advance in overcoming the interruptions of service due to strays, but details are at present withheld.

The problem of eliminating altogether the effect of strays on the receiver is at present the paramount one in long-distance wireless telegraphy, as they are a source of far greater difficulty than in short-distance working.

A Journal for Physical Measurements and Instruments.

READERS of NATURE, whether physicists or others, will be interested to learn of the steps which are being taken and the progress which has been made in connection with the proposed new journal dealing with physical instruments, the first important task which the newly founded Institute of Physics has set itself to accomplish. At the National Physical Laboratory the need for such a journal has long been felt; accordingly in 1919 the director addressed a letter directing attention to the needs of a number of Government departments and workers in various branches of science.

The response was most gratifying. The Admiralty, War Office, Ordnance Committee, engineering department of the Post Office, and other important bodies, all wrote approving the suggestion and in many cases offering support, while men of science—physicists, physiologists, miscroscopists, zoologists, and engineers—warmly commended the scheme, which also received the support of some leading instrument makers, including the British Optical Instrument Makers' Association and the British Electrical and Allied Manufacturers' Association. As a result the Institute of Physics brought the proposal before the Department of Scientific and Industrial Research. A meeting was held between representatives of the department and of the institute under the chairmanship of Sir J. J. Thomson, at which a suggestion was made that a single number might be prepared and issued as a specimen with the view of seeing what support could be obtained.

This suggestion was, at a later date, conveyed in a more formal manner to the department and approved by their advisory council, and a joint committee appointed by the department, the National Physical Laboratory, and the institute has been formed to give effect to it.

The institute has accepted financial responsibility for the publication of the journal provided scientific and industrial associations and individuals to whom the journal will be of service are prepared to furnish adequate guarantees for its support. The department will make a grant towards the cost of printing the specimen number.

The institute is to have the assistance of the staff of the National Physical Laboratory in the preparation of this number, and Dr. Rayner has, at the request of the committee, undertaken the duties of editor. An announcement of the proposed journal has been prepared and will be widely circulated along with a request for support, and it is hoped that the response will be such as to enable the institute to continue the task it has set itself and produce a work which will fill the acknowledged need.

Obituary.

SIR HENRY JONES.

IN Sir Henry Jones, professor of moral philosophy in the University of Glasgow, who died on February 4 at his home in Argyllshire, we lose one of our greatest teachers and, since Edward Caird, the leading representative of the Hegelian influence and tradition in English university life. A pathos surrounds the last few years of his life and also throws light on his personal character and strong mentality. He struggled against the painful disease which has proved fatal with a courage nothing short of heroic. He refused to give up, or even to slacken, his regular work. He persevered with his last undertaking, the Gifford lectureship, under conditions which few could have endured. He lectured even when speech was becoming